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## ADDITIONAL NOTICE.

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*On some superficial Geological Appearances in North-Western Morocco, abridged from Notes taken during the late Mission of Sir Moses Montefiore to Morocco.* By Dr. T. HODGKIN.

THE encroachment on the beautiful and productive face of the country by sand, brought upon it by north-western winds, is a remarkable phenomenon, which, as it must tend to the rapid deterioration of the country, is worthy of special attention. The ravages are most striking in the neighbourhood of Mogador. The left or north side of the harbour consists of sandstone rock; but to the right or south side we see nothing but a flat plain of sand, behind which rise low bare sand-hills. On the left we have low cliffs, rising some feet above the sea, consisting of the before-mentioned sandstone, upon which rests a bed of water-worn stones, of various sizes, feebly held together. There is a thin strip of this elevated land running along the coast, where it forms the commencement of the route to Saffi. Shortly after quitting the Saffi gate we come upon a long series of graves lying between the road and the sea, partly belonging to the Israelite and partly to the Christian cemetery. The very ponderous and thick gravestones by which the European graves are generally covered are in several instances thrown down or greatly displaced, obviously owing to the undermining of the bed of shingle and boulders, which is in different degrees of progress and threatens the destruction of the cemetery itself. The destruction of this part of the coast is evidently owing to two causes. Though the sandstone-rock affords some resistance to the sea, the larger waves, when they dash against the shingle-bed, disintegrate and loosen it, and the action of the north-west wind, following upon this disintegration, carries the particles of sand inland. It is impossible to say to what amount of sterility the transport of this wind-borne sand may bring this fertile country. The accumulation of sand is already very considerable. A small palace by the seaside, built by the Sultan who founded Mogador, is rendered untenable and useless by the sand, which has nearly filled some of the apartments and raised such a mound on both sides of the enclosing wall that, although about 18 feet high, it may be walked over without a ladder. The sand has also been carried for miles into the interior, forming hills of considerable height; and the road from the city towards Morocco, instead of passing directly towards the Mogador River, now takes a somewhat winding course near the shore. A very small object is apparently sufficient to check the progress of the sand in its eastern course. On some of the hills near the coast the white broom abounds, acquiring a height of 8 or 10 feet, and is useful in retarding the encroachments of the sand, so that it is not improbable that by judicious planting in particular spots the advancing injury might be checked.

Whilst examining the sandstone rocks near Mogador, my attention was caught by a thin stratum of limestone, which not only partially covered them but also penetrated into their fissures and crevices. I found afterwards in the course of the journey to the city of Morocco and thence to Mazagan that this limestone covering was spread over the greater part of the surface of the country, and came to the conclusion that it was due to the deposition of carbonate of lime (mostly very impure) by water which had held it in solution; in short resembling travertine, but less crystalline and probably of a tufaceous nature.

What I observed seemed clearly to indicate that the depositing water must have risen to a considerable height ; it having left the deposit on high land, and even on the sides of hills of considerable elevation. Yet the deposition must have been long subsequent to those commotions of the earth's surface by which the older rocks have been brought into their present positions. Unequivocal evidences of the course taken by the flowing water may be found in the water-worn fragments of older formations which it has brought along with it and left enclosed in its own deposit. Thus, in advancing from the coast towards the interior, we found fragments of rocks ; at first few and small, but gradually increasing both in size and number. Whenever we had crossed the region whence some of them were derived we failed to find any more fragments of those particular rocks beyond it. Although our course lay towards the Atlas range, I do not believe we were advancing exactly in the direction from which the water flowed ; for although the water-worn fragments of porphyry increased in size and number till they formed almost exclusively the mass of the materials, they were by no means generally of that description of porphyry which might be expected to occur in the nearest portion of the Atlas. Green porphyry was the prevailing rock transported, whilst brown, red, and liver-coloured porphyries abounded in the bed of the river Nefis, proceeding from the nearest part of the range. The following are some of the facts which I observed with regard to this extensive deposit, arranged in the order in which they occurred. Amongst the loose stones strewn over the ground near Mogador, I saw very many which were evidently fragments of stalactites, although they had not a crystalline appearance. I have now no doubt that they belonged to the superficial deposit in question, and were connected with some fissure or cavern existing at the period when Mogador Island may have joined the mainland. At no great distance inland it became evident that we were coming on a limestone country ; and the rock being to a great extent almost bare, its character was exposed, showing a large, flat, reniform surface in layers, though not crystallised. I was then struck with its resemblance to the travertine of the neighbourhood of Rome. Large portions appeared undisturbed, or at least unbroken ; others exhibited cracks, without much displacement. On again reaching the Mogador River we found it flowing between precipitous banks, showing the strata of alluvium resting on the travertine. We forded it at a part where the exposed travertine, or tufa, was several feet in thickness and formed steps. It was composed of rounded pebbles of different kinds, and my notes mention shells also, cemented by the travertine. Amongst the pebbles I noticed flint, chert, or chalcedony, some of which had evidently been derived from seams or veins, and also fragments of hæmatite. In the low ground, through which the river passes, the bed of alluvium resting on the travertine is of considerable thickness, but on the higher spots the travertine is either as bare as a flagstone pavement, or covered with the numerous fragments into which the layers separate. A few miles beyond the Mogador River the path is over a true limestone country. The strata were distinctly inclined (natural sections on the banks of a stream affording a good opportunity for observation), and where the outcropping edges formed steps the travertine appeared as a continuous covering to them, like a piece of carpeting on an ordinary staircase. Some of the fragments of travertine met with on the march in particular localities were more or less globular masses which did not owe their figure to attrition, since, when broken, they were found to consist of concentric layers deposited upon a nucleus of softer substance. These seemed to indicate both the motion of the depositing fluid and the rapidity with which it must have precipitated the earthy matters which it held in solution. One of the localities which furnished these specimens was near Ain Oumast. The upper or later layers of the travertine or tufa formation are by far the purest, that is to say, the most exempt from foreign matters, and their character is remarkably uniform throughout the extensive district which they overspread. The lower beds, on the contrary,

are the most varied, both as respects their own character and that of the included fragments. Proceeding from Sidi Mokhtar the route leads towards a group of conical flat-topped hills. Fragments of chalcedony were here found scattered about. Many of the masses were a foot or more in diameter, and when fractured exhibited concentric lines like agate, the colour being chiefly grayish-white. Their external surface was remarkably fresh; in some it was minutely mamillated and on others there was an approach to crystallisation. Some masses were nearly or quite solid, whilst others had cavities lined either with chalcedony, crystallised quartz, or containing a light cellular siliceous material. To complete the description of these siliceous nodular masses I must give some account of the conical hills already alluded to. They appeared to consist of a white limestone, much resembling chalk; and it was evident that the flat, well-defined, almost horizontal summits were determined by a thick bed of a siliceous or cherty character. Other layers of the same character and parallel to it were seen, in some cases, lower down the hill. Where the uppermost layer had been wholly removed the table-like form was lost. I had no opportunity of ascending any of these hills on our road to Morocco; but on returning I explored one of them near Smira which had had its upper layers removed. One side formed a low cliff, exposing not only a section of the limestone but also a layer of the travertine resting upon it. Impressed by the idea that the nodules, like the flint layers, had been formed in the limestone, I perseveringly sought for them *in situ*; but, although numbers were lying on the ground, I could not find a single one in the limestone cliff. I found, however, one or more specimens embedded in the undisturbed conglomerate bed beneath the upper layers of travertine. I had no conception of their having been formed subsequently to the disintegration of the limestone until after my return to England, when I showed the specimens I had brought with me to my friend W. Pengelly, F.R.S., who immediately recognised them as Beekites, resembling those he had found in conglomerate beds in Devonshire. There seems, however, to be a marked difference between the Beekites of Devonshire and those of Morocco. The former would seem to be formed by a process investing a nucleus of so frail a character as frequently to leave a cavity produced by its decay. Now very many of the Beekites of Morocco have a decidedly stalactitic character, and one of the small specimens which I brought home exhibits the siliceous matter so formed upon a fragment of the hard limestone, that it accounts at once for the absence of any coating of silicate of lime and for the freshness of surface which is so remarkable a character of the siliceous masses when dislodged from the bed in which they had been contained. If I may be allowed to offer a conjecture as to the process by which these concretions of siliceous matter have been formed, it would be that a very large tract of a limestone formation has been broken up, leaving, at intervals, those portions which we now see as table-topped and round-topped hills. That this limestone abounded in siliceous matter is evident from the thick layers of flint, petrosilex, or chert, conspicuous in some of these hills. The process of solution and segregation, being continued or renewed in the vast quantity of disturbed limestone, seems to have allowed of its deposition in the cavities left between the broken fragments. Beekites are found there under the two forms which I have noticed. I may observe that for about half a mile in which I traced the travertine in close proximity to the undisturbed limestone-rock near Smira I remarked a layer of crystallised carbonate of lime in the form called dog's-tooth spar, which formed a continuous horizontal line. By the term "conglomerate bed" I wish to designate the under portion of the travertine or tufa which covers so large a portion of the face of the country. It differs in the foreign materials which it encloses, and also in the characters proper to itself. At the camping-place of Minzala Emzody, by the side of a small stream, the ground to the east rises in low hills of a remarkable white colour, which seemed to me to consist chiefly of the upper portion of a deep conglomerate bed. The lower portion was full of water-worn fragments of porphyry.

The striking peculiarity of this upper portion was its great tendency to disintegration. Water seems freely to filter through this travertine; the stream by our encampment issued from pits which have been sunk in it, and it is probable that many of the wells of the country derive their water from the conglomerate bed. In some places advantage is taken also of this compact covering over an easily excavated softer stratum for the formation of aqueducts, which are most numerous and remarkable near the city of Morocco. Numerous pits are excavated in a line across the country, and communicate with each other by shafts underground. In the channels thus formed an abundant supply of water is conveyed from the mountain district, not only to the city but also to the olive and orange orchards. Much as these aqueducts are worthy of admiration, they are open to one serious objection. They entail an enormous and incalculable amount of waste of water by transmitting it through a porous stratum, viz., that beneath the continuous and more solid upper layer of travertine.

Near our camping-place, Minzala Emzody, we found, on one of the higher hills, a series of highly-inclined strata, chiefly of marble of a brownish colour, alternating with a darker and harder rock. One of our companions, Archibald Fairley, an experienced engineer, who was about to enter the service of the Sultan, made the interesting discovery that this marble had at one time been quarried for building material. The mode of working seems to have been very simple, and also very saving of material and labour. It consisted in making a channel in the direction of the intended cut of a block, about three or four inches broad, and pierced with holes in the bottom. A. Fairley conjectured that wooden wedges were driven into these holes, and that water was poured in the groove above, by which the wood became swollen till it caused the cleaving of the stone. Besides several large blocks wholly detached or only unfinished, we found, in the valley below, one piece apparently designed for a column, ten feet long, and with a proportionate diameter. Neither in the vicinity nor elsewhere—even in the city of Morocco, where the remains of worked marble are to be seen—did we find any example of the working of this marble. In fact, we could gain no further information respecting it beyond that which was furnished by our own eyes.

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